**Appendix A.** Here we give the matrices used in CLM4cn and DAYCENT.

**A.1 CLM4cn**

CLM4cn has eight carbon pools defined as

|  |  |
| --- | --- |
| Pool | Variable |
| labile litter | x1 |
| cellulose litter | x2 |
| lignin litter | x3 |
| coarse woody debris | x4 |
| soil organic matter, SOM1 | x5 |
| soil organic matter, SOM2 | x6 |
| soil organic matter, SOM3 | x7 |
| soil organic matter, SOM4 | x8 |

**a)** Matrix represents the  carbon pools (g C m–2) as a  column vector:



**b)** Matrix represents the  litterfall fluxes (g C m–2 yr–1) as a  column vector:



where is leaf litterfall, is fine root litterfall, and is coarse woody debris.

**c)** Matrix  is a  litter flux partitioning matrix in which  is the partitioning of litter flux *j* to pool *i*:



**d)** Matrix  is a  diagonal matrix in which  is the base fractional loss for pool *j* (yr–1) and all other elements are zero:



**e)** Matrix  is a  diagonal matrix in which is the environmental scalar for pool *j* and all other elements are zero:



Here,  is a scalar that accounts for soil temperature () and soil water potential () effects on decomposition rates, and  is the reduction in nitrogen-optimal decomposition rates (ranging from 0 to 1) and represents the fraction of potential immobilization allowed by the available nitrogen. We performed CLM-cn simulations with , as discussed by *Bonan et al*. [2013]. The temperature scalar is:



for  (°C) and . The soil moisture scalar is:



with  soil water potential,  soil water potential at saturation, and  MPa the water potential when the soil is dry.

**f)** Matrix  is a  carbon transfer matrix in which  for pool *j* and  is the fraction of carbon loss from pool *j* entering pool *i* (for ):



The off-diagonal terms are , where  is fraction that transfers from donor pool  to receiver pool  and  is the fraction of the flow to the receiver pool lost as respiration. for all flows except coarse woody debris ( and ). Hence,  except for coarse woody debris ( and ).

**A.2 DAYCENT**

DAYCENT has twelve carbon pools defined as

|  |  |
| --- | --- |
| Pool | Variable |
| metabolic litter, surface | x1 |
| metabolic litter, soil | x2 |
| structural litter, surface | x3 |
| structural litter, soil | x4 |
| CWD, fine branch | x5 |
| CWD, large wood | x6 |
| CWD, coarse root | x7 |
| SOM1 (active), surface | x8 |
| SOM1 (active), soil | x9 |
| SOM2 (slow), surface | x10 |
| SOM2 (slow), soil | x11 |
| SOM3 (passive) | x12 |

**a)** Matrix represents the  carbon pools (g C m–2) as a  column vector:



**b)** Matrix represents the  litterfall fluxes (g C m–2 yr–1) as a  column vector:



where is leaf litterfall, is fine root litterfall, is fine branch coarse woody debris, is large wood coarse woody debris, and is coarse root coarse woody debris.

**c)** Matrix  is a  litter flux partitioning matrix in which  is the partitioning of litter flux *j* to pool *i*:



Here,  is a function of the lignin/N ratio of the leaf and fine root litterfall.  is the fraction of litterfall to metabolic litter, and  goes to structural litter.

**d)** Matrix  is a  diagonal matrix in which  is the base fractional loss for pool *j* (yr–1) and all other elements are zero:



The base loss  is additionally enhanced for mixing from the surface slow pool () to the soil slow pool (). This enhancement is included in the environmental scalar  and depends on a mixing rate (= 0.25 yr-1 in our simulations).

**e)** Matrix  is a  diagonal matrix in which is the environmental scalar for pool *j* and all other elements are zero. The diagonal entries are:



















Here,  is the temperature and moisture scalar as in CLM4cn;  is the lignin fraction of the pool ( = 0.25 for coarse-woody debris);  decreases decomposition rates for anaerobic conditions (=1 in our simulations); and  increases decomposition rates for cultivation (=1 in our simulations). In calculating the environmental scalar for  (soil active pool), the factor  varies the decomposition rate in relation to the sand fraction (). For  (surface slow pool), the mixing to  (soil slow pool) enhances the base loss  in relation to .

The pH effect is given by the function:



Parameter values are: , , , and . For metabolic litter (, ) and the soil active pool (),  and . For the passive pool (), .

**f)** Matrix  is a  carbon transfer matrix in which  for pool *j* and  is the fraction of carbon loss from pool *j* entering pool *i* (for ):



Here,  is fraction that transfers from donor pool  to receiver pool :



The transfer of structural litter (,) to soil organic matter depends on the lignin fraction of the structural litter (), as does coarse woody debris (,,) with = 0.25. The transfer from the active () and slow () pools to the passive pool () varies with clay fraction:



The fraction of the loss from the surface slow pool () that goes to the soil slow pool () via mixing is:



The first term in the denominator is the base decomposition loss (modified by pH) and the second term is the mixing rate. The mixing fraction is equal to the proportion of the total loss, , that is due to mixing, . The remainder, , decomposes to the surface active pool ().

The fraction of the flow to the receiver pool lost as respiration () is:



with , , and  the sand fraction.

**A.3 Modifications for simulating deeper soil horizons in DAYCENT (“deep” DAYCENT)**

Base loss rates of the belowground active () and slow () pools were decreased by 40%:



The transfer from the active () and slow () pools to the passive pool () was increased by 40%:

